Team Number _____

This is the Dynamic Planet (Earthquakes and Volcanoes) test for Division C.

You may divide up the test, but if you do, please put your team number on every page.

The tiebreakers on this test are

1. The total score on Section B (the short answer section)
2. The score/completeness of answer on problem C.3.
3. The total score on Section D
4. The total score on Section A

Thank you for putting in the time to learn about this field. I hope that you find this test challenges you to put what you've learned into context.

Good luck!

Scores:

_____ A (15 points)

_____ B (30 points)

_____ C (25 points)

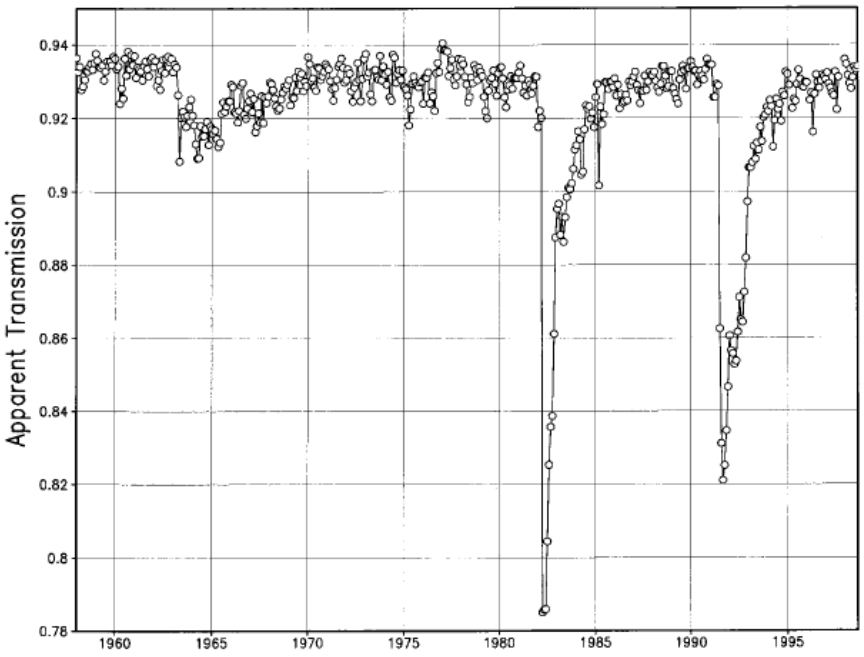
_____ D (20 points)

_____ E (10 points)

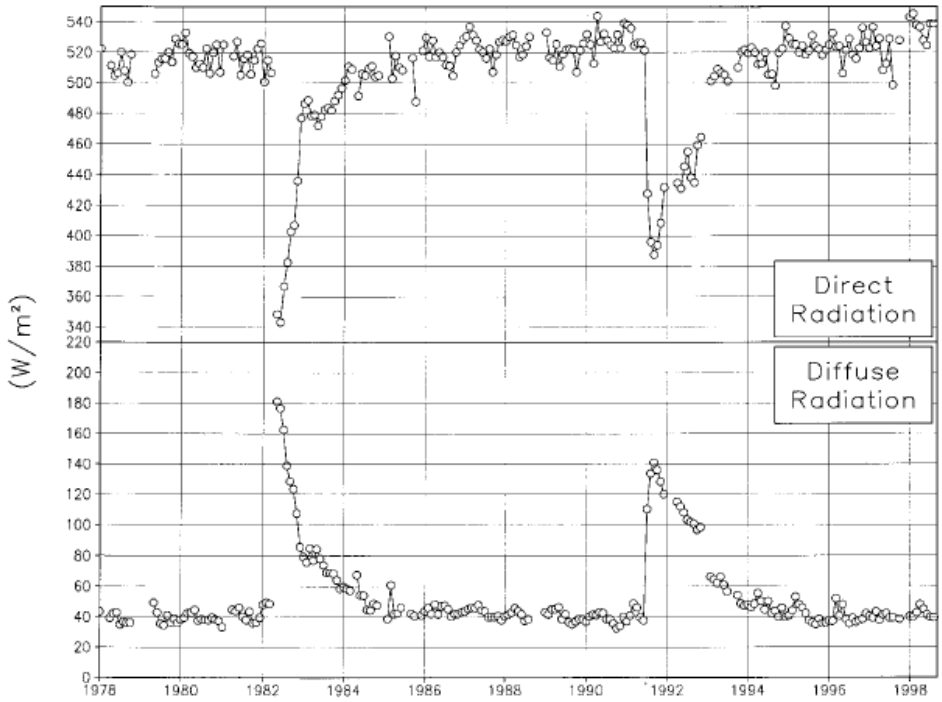
_____ TOTAL

Volcanic eruptions and climate (15 points)

The following plots are used in this section



Apparent atmospheric transmission at Mauna Loa Observatory, HI since 1958.



Direct (from face of sun) and diffuse (excluding face of sun) solar radiation at the same site. Note different time scale. Plots from Robock
http://climate.envsci.rutgers.edu/pdf/ROG2000.pdf

1..What events do you see in these time series? Compare and contrast the events and link them to specific volcanic eruptions if you can. (5 points)

There are sharp decreases in apparent transmission in 1982 (associated with El Chichon) and 1991 (associated with Mount Pinatubo) which correspond to decreases in the direct solar radiation but *increases* in the diffuse radiation. The El Chichon event is initially larger, but decreases to half it's initial value after about 1 year, while the Pinatubo event takes two years to decrease to ½ its initial value. (Give 1 point for each eruption correctly mentioned, 3 points for the completeness of the description).

2. Describe the *net* impact of the second eruption on the total solar radiation reaching the surface. (5 points)

The initial effect is to decrease the solar radiation hitting the surface, with a decrease of 140 W/m^2 in the direct but an increase of only about 100 W/m^2 in the diffuse component. By early 1992, the two components are almost in balance. (Give half credit for mentioning the initial decrease, half credit for noting that the two come back into approximate balance).

3. What constituent(s) emitted by volcanoes account for this signal? (5 points)

Ash accounts for some part of the initial signal (give 2 points if this is all that is mentioned), but most of the signal is due to sulfur dioxide which produces aerosols that scatter sunlight (give 4 points for mentioning this, full marks for particularly full explanation of what it does or for mentioning both ash and sulfur dioxide).

B: Short answer (5 points each)

1. Is the lava flow below an example of a dike, a'a, lahar deposit, or pahoehoe? How do you know?

The feature is an a'a', which is composed of rough blocks, rather than continuous deposits. (3 points for ID, 2 points for explanation)

2. The picture below shows a feature known as a lava tube. How do such tubes form?

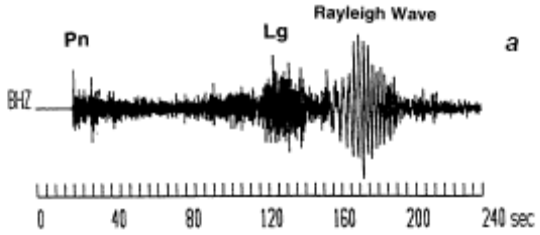
Lava tubes form when lava around a flow hardens, but the lava within the tube continues to flow, eventually slackening.

3. The rock on the left is an example of kimberlite (note the reddish and greenish crystals embedded in it). How is kimberlite formed and why are deposits of it so sought after?

Kimberlite is formed in an eruption that produces a vertical "pipe" of material rising from deep magma reservoirs. (2.5 points). It is particularly associated with diamond deposits.

4. What feature of seismic wave propagation provides evidence of a liquid core on earth?

The fact that S waves do not propagate through the core, and so are not seen on the other side of the earth from a quake.



5. The picture above shows a seismic trace from the Indian nuclear test in 1998. Why are nuclear explosions particularly likely to generate Rayleigh waves?

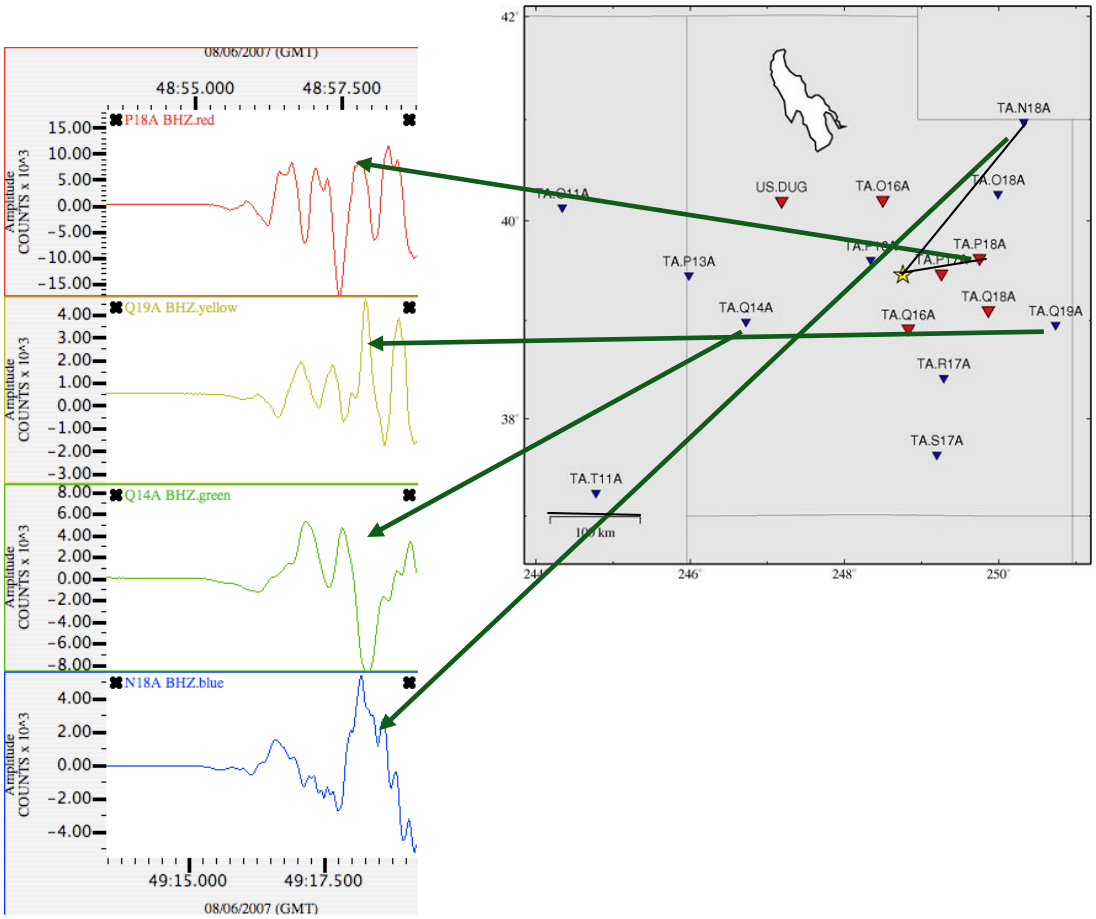
OK this ended up being a bit of a trick question. Nuclear explosions occur close to the surface compared with many quakes, which are occur many kilometers beneath the earth's surface and this feature makes them more likely to generate Rayleigh waves. However- because of the relatively small lateral scale of the eruption, nuclear explosions are actually less like to generate Rayleigh waves than earthquakes, and the ratio between surface wave magnitude and body wave magnitude is one of the principal means used to distinguish between nuclear explosions and earthquakes.

6. Using the moment magnitude scale, how much more energy does a magnitude 7.0 earthquake release than a magnitude 5.0 earthquake?

900-1000 times more energy.

C. Interpreting seismograms (25 points)

On August 8, 2007, a collapse, killing 6 miners, occurred at the Crandall Canyon Mine (yellow star below right). A number of seismographs were deployed in the area, and recorded this event as having a magnitude of 3.9. The graphs on the left show the vertical displacement associated with each of these seismographs.



1. Noting the scale bar in the bottom left of the picture (100km) and the time scale on the top and bottom seismograms, estimate the P-wave velocity in this area. (5 points).

Distance to the first seismic station is just under 100km. Distance to the second is a bit over 200 km. Difference in the arrival time is about 20 seconds. So the speed is ~5 km/s.

2. What are the physics behind P-wave propagation? (5 points)

P-waves are sound waves- a series of compressions and rarefactions in the rock. High pressures associated with compression generate outward flows, which then overshoot and generate low pressures associated with stretching.

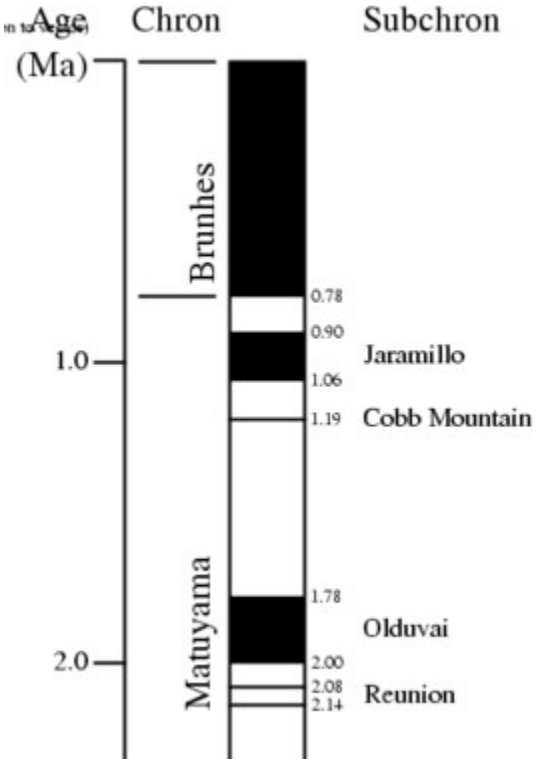
3. The mining company claimed that this disaster was caused by an earthquake, but seismologists disagreed. Describe the pattern of initial vertical displacements that would be associated with a collapse, left-lateral slip along a north-south fault, and right-lateral slip along an east-west fault and evaluate whether it fits the data. (4 points for describing each pattern, 1 point for evaluating whether each one fits)

A collapse would generate an initial low pressure wave radiating out in all directions, as is seen in the seismographs.

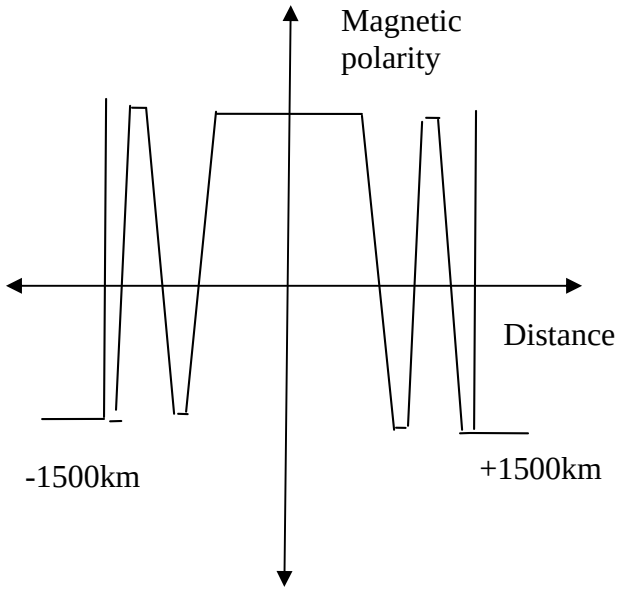
A left-lateral slip on a north-south fault would generate compressions (highs) moving to the northeast and southwest and lows moving to the southeast and northwest. Thus one would expect different signals at the bottom two seismographs.

A right-lateral slip along an east-west fault would generate the same pattern of highs and lows as the previous one, and so one would again expect different signals at the bottom two seismographs.

D. Magnetic reversals and plate tectonics (15 points)



The plot on the left shows magnetic reversals over the past two million years. Use this data to develop a plot of magnetic field vs. distance as you cross a mid-ocean Ridge for crust created within the past 1.5 million years. Label the horizontal axis!



(Note, in order to solve this problem you will need to know the average speed of a spreading center). What is it?

Average speed is around 10 cm/yr or 0.3 mm/day. Accept answers within a factor of 3 of this (0.1-1 mm/day, 3-30 cm/yr and scale appropriately) Give 5 points for getting the horizontal scale correct, 3 points for getting the symmetry correct, and the remaining points for overall accuracy.

E. Identification (3 points each)

1. Nuee ardente: A glowing avalanche of ash, pumice and hot gases, a type of pyroclastic flow.
2. Richter scale: A logarithmic scale for earthquake magnitude, determined in terms of the movement of a standard seismograph at 100km from the epicenter.
3. Tsunami: A long ocean gravity wave produced by earthquakes.
4. Stratovolcano: Also known as a composite volcano- formed by alternating layers of lava and rock fragments.
5. Transform fault: A fault that involves two plates moving past each other. One of the principal types of transform fault is that where plates are moving apart from a spreading center.